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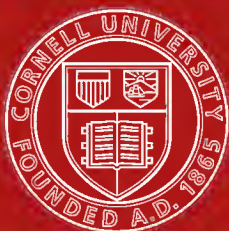


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IMPERIAL MINERAL RESOURCES
BUREAU.

THE MINERAL INDUSTRY OF
THE BRITISH EMPIRE

AND

FOREIGN COUNTRIES.

WAR PERIOD.

ASBESTOS.

(1913-1919.)



LONDON.

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PREFACE.

The following digest of statistical and technical information relative to the production and consumption of Asbestos will constitute a part of the Annual Volume on the Mineral Resources of the British Empire and Foreign Countries.

In this, the first year of publication, an effort has been made to fill in, as far as possible, the hiatus due to the war in the publications relating to mining and metallurgical statistics. Labour, health, and safety statistics have been omitted owing to the difficulty involved in procuring reliable information for the war period, but in future issues these statistics will be included in respect of each year. Resort will also be had to graphical representation of statistics of production, consumption, costs, and prices.

The weights are expressed in long tons, that is to say the British statute ton of 2,240 lb., and values in pounds, shillings, and pence.

R. A. S. REDMAYNE,

Chairman of the Governors.

2, Queen Anne's Gate Buildings,
London, S.W.1.

December, 1920.

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GENERAL.

The name asbestos is applied to several fibrous silicate minerals, which differ from one another in their chemical composition and physical properties. The asbestos of commerce includes serpentine asbestos or chrysotile, and several kinds of amphibole asbestos, including tremolite, actinolite, crocidolite, amosite, and anthophyllite. Of these commercial varieties of asbestos, chrysotile has hitherto been of chief importance, on account of its superior refractory quality and strength of fibre. Next in importance to chrysotile come crocidolite and amosite. Tremolite, actinolite, and anthophyllite are comparatively unimportant.

Chrysotile or serpentine asbestos (originally known as karystiolite) is essentially a hydrated silicate of magnesium. It occurs in serpentine rock in the form of thin parallel or interlacing veins. It has great tensile strength and flexibility, resists attack by acids, and has remarkable fire-resisting qualities, though it dehydrates and loses its tensile strength at a temperature of about 500° C. It is a good insulator for both heat and electricity and is well adapted for spinning.

For many years chrysotile has been the principal asbestos mineral used in commerce. The fibre in chrysotile is usually of the cross-fibre type, *i.e.*, it lies at right angles to the vein in which it occurs. The length of the fibre varies. The great bulk of the asbestos mined contains fibres half-an-inch or less in length. Great improvements have been made in the art of spinning short chrysotile fibre, and lengths not exceeding three-eighths of an inch can now be spun.

Crocidolite or blue asbestos, a silicate of iron and sodium, has been found in large quantities only in South Africa, where it occurs in narrow interbedded cross-fibre veins traversing the Lower Griqua Town series of banded jaspers and magnetic ironstones. The fibre rarely exceeds 3 inches in length, but fibres $\frac{3}{4}$ -inch to $1\frac{1}{2}$ inch in length are common. It has great heat insulating capacity, but its fire-resisting qualities are poorer than those of chrysotile. Asbestos cloth, rope, felt, etc., can be manufactured from crocidolite fibre, as also can sheets, tiles, cement, and other building materials. It finds an increasing use for boiler and steam-pipe lagging, and for electrical insulation.

Amosite is found in the north-eastern Transvaal and is apparently a new form of amphibole asbestos. It is closely similar to crocidolite in structure and mode of occurrence, but is of greyish, greenish, or yellowish colour. The fibre possesses tensile strength and flexibility to a marked extent, though not to the same degree as chrysotile. Its insulating and acid-resisting qualities are high. Mining operations on a commercial scale for amosite were not commenced until 1915, and, consequently, the economic value of this mineral has not yet been adequately established. It has, however, already found a considerable market in America and Japan.

Tremolite is a white silicate of magnesium and calcium, and the fibres of the asbestos variety have a fine, silky texture. The fibres are usually weak, but they possess good insulating and acid-resisting qualities. Tremolite forms the larger proportion of the Italian production of asbestos. In Natal, a little tremolite is quarried for the manufacture of asbestos tiles, cement, and similar materials.

Actinolite is a green variety of tremolite, containing an appreciable percentage of iron oxide. It is of little commercial importance. A fibrous form, quarried near the village of Actinolite in Hastings County, Ontario, Canada, is used for boiler coverings and asbestos plaster.

Anthophyllite is a silicate of magnesium and iron. It is quarried chiefly in the States of Georgia and Idaho in the United States. The product from the quarries is too brittle and has too short a fibre to be used for any other purpose than boiler-packing, and the manufacture of asbestos plaster, tiles, etc.

The following analyses show the differences of chemical composition among the several kinds of asbestos:—

	Chrysotile, E. Brough- ton, Canada.	Tremolite (theo- retical).	Crocidolite, Cape Colony.	Amosite, Transvaal.	Anthophyll- ite, Georgia, United States.	Actinolite, Hastings Co., Canada.
	per cent.	per cent.	per cent.	per cent.	per cent.	per cent.
Silica ...	41·90	57·80	51·10	50·85	57·12	61·82
Alumina ...	0·89	—	—	0·69	0·75	1·12
Ferrous Oxide.	0·69	—	35·80	38·37	6·36	6·55
Lime ...	—	13·43	—	—	—	1·63
Magnesia ...	42·50	28·77	2·30	6·95	29·44	23·98
Soda ...	—	—	6·90	0·21	—	—
Water ...	14·05	—	3·90	2·81	5·47	5·45

The commercial value of asbestos depends chiefly on tensile strength, flexibility, fineness of fibre, dehydration temperature, and temperature of fusion. Other qualifying factors of some importance are heat-insulating capacity, electrical insulating power, and colour.

The uses to which asbestos fibre is now put are so various that the whole of these qualities are not essential for every industrial purpose. Where asbestos is required for spinning and weaving into asbestos fabrics, ropes, and engine packing, the qualities of first importance are tensile strength, fire-resistance, and length of fibre. Such articles form only a small proportion of the total output of asbestos manufactures. The larger proportion of the asbestos mined is used in the building and engineering trades. The building industry does not require long fibre in the raw material used. Lengths from $\frac{1}{8}$ inch upwards are suitable for the manufacture of sheets, tiles, and slabs. It should be remarked, however, that although the asbestos consumed in the textile trades is smaller in quantity than that consumed in the building trades, it is greater in value.

In the engineering trade, asbestos millboard is extensively used as a joint-packing for steam pipes, cylinders, steam chests, etc. By special treatment asbestos millboard can be made completely watertight. Loose asbestos fibre, and asbestos pressed into sheets or made into mattresses, are widely used for covering steam-pipes and boilers, particularly in connection with marine engines.

As an insulating material asbestos is widely used in the electrical industry. For this purpose the asbestos is manufactured into boards and sheets, or pressed into the shape of the article to be covered.

Finely ground anthophyllite, low-grade tremolite, and the residues from the chrysotile mills, find extensive application in the manufacture of asbestos cement, fire-proof bricks, tiles and other roofing material. Wall plasters and similar fire-proof material are manufactured from very fine asbestos fibre mixed with serpentine. A similar product is used in the construction of cold storage buildings. Nearly all these have double walls packed with some kind of non-conducting material surrounding the cold chambers.

There are many fire-proofing materials on the market which have asbestos as their chief ingredient. These usually take the form of asbestos felt or sheets, reinforced with asbestos cloth or asbestos paper, and are used for ceilings, wainscoting, and similar inside decorative work.

Asbestos paints are made in various colours. They have remarkable fire-resisting qualities, and are suitable for all kinds of rough woodwork. Asbestos wool mixed with a solution of sodium silicate makes a fire-proof cement of great strength. It can be made insoluble by subsequent treatment with calcium chloride, silicate of calcium being formed.

Asbestos reduced to a fibrous powder, mixed with powdered clay and refractory earths, made into a paste with water, dried and burned, furnishes a valuable refractory material.

WORLD'S PRODUCTION.

Before the war Canada held first place as a producer of asbestos, Russia stood second, and South Africa third. During the period under review Canada continued to produce nearly 80 per cent. of the world's output of asbestos, but the Russian production declined. It is probable that at the present time South Africa occupies the second place as regards output. Russian figures for the period under review are not available, but it is unlikely that the asbestos mines were worked to any considerable extent during the war.

The United States of America is the chief consumer of unmanufactured asbestos. England is the next largest importer, followed by Japan, France, Italy, Austria, and Germany.

The commercial grades of asbestos are numerous, and have been standardized only to a limited extent; they vary in value from about £5 per ton for very short fibre, low-grade mill-stock,

to over £800 per ton for selected high-grade fibre over 2 inches in length (November, 1920).

World's Production of Asbestos.

In long tons.

	1913.	1914.	1915.	1916.	1917.	1918.	1919.
Southern Rhodesia.	259	435	1,795	5,497	8,537	7,655	8,696
Union of S. Africa.	859	1,063	1,909	4,157	5,554	3,280	3,512
Canada ...	118,361	96,133	95,142	105,578	126,556	128,086	136,669
Cyprus (exports).	1,168	246	1,099	1,291	1,069	228	1,331
India ...	—	5	—	—	148	357	388
Australia ...	—	—	1	36	281	3,034	1,790
Italy ...	172	168	160	81	84	59	
Russia ...	17,218	15,444	8,551	8,062			
United States	982	1,113	1,546	1,321	1,503	895	1,261

BRITISH EMPIRE.

The largest and most valuable deposits of asbestos occur within the British Empire. Canada has long been the chief producer of chrysotile asbestos. The Union of South Africa is the only producer of crocidolite and amosite. Increasing quantities of high-grade chrysotile have been produced in recent years from the large deposits in the Victoria and Belingwe districts, Rhodesia, and there is a small output at Amiandos, near Troodos, in Cyprus. Most of the asbestos mined in Australia is used in the manufacture of asbestos cement sheet. India produces a small but increasing quantity of asbestos from deposits in Mysore, and efforts are being made to establish an asbestos manufacturing industry in that State. Asbestos is known to occur in a belt of serpentine rocks along the west coast of Newfoundland, as well as in the interior, but there was no production during the period under review.

Very little of the asbestos produced within the British Empire is worked up within the country of origin. Most of the Rhodesian and South African asbestos is exported to Great Britain and other parts of Europe for treatment, while the Canadian output is exported largely to the United States, and in smaller quantities to the United Kingdom.

United Kingdom.*

Asbestiform minerals occur only sparingly in the United Kingdom, and no deposit of economic value is known.

Large quantities of unmanufactured asbestos are imported from all the chief producing countries, and the United Kingdom stands second to the United States as a producer of asbestos manufactures.

* Annual Statements of the Trade of the United Kingdom.

Imports of Unwrought Asbestos into the United Kingdom.

From	Quantity (long tons).						
	1913.	1914.	1915.	1916.	1917.	1918.	1919.
Russia	1,580	1,253	205	2,569	—	97	—
Germany	350	265	—	—	—	—	—
Portuguese East Africa.	193	294	711	2,705	1,397	3,027	205
Italy	91	75	35	35	34	42	10
United States of America.	1,106	1,607	3,305	3,523	777	272	867
Other Foreign Countries.	155	153	404	214	307	—	2
Total from Foreign Countries.	3,475	3,647	4,660	9,046	2,515	3,438	1,084
Cape of Good Hope	566	832	2,713	3,264	2,493	1,781	1,900
Natal	4	71	320	30	79	56	418
Rhodesia	17	—	78	2,045	2,812	4,554	6,190
Canada	7,539	10,113	17,493	12,247	7,440	9,941	7,354
Other British Possessions.	1	51	259	80	97	117	723
Total from British Possessions.	8,127	11,067	20,863	17,666	12,921	16,449	16,585
Total ...	11,602	14,714	25,523	26,712	15,436	19,887	17,669
	Value (£).						
Russia	44,993	28,782	3,990	74,837	—	2,297	—
Germany	8,391	9,074	—	—	—	—	—
Portuguese East Africa.	4,063	5,845	15,187	77,216	50,531	117,820	9,972
Italy	2,600	4,342	1,581	1,186	1,074	8,568	900
United States of America.	5,671	16,583	35,897	37,251	11,916	7,486	27,120
Other Foreign Countries.	2,464	2,685	1,538	5,196	6,329	—	295
Total from Foreign Countries.	68,182	67,311	58,193	195,686	69,850	136,171	38,287
Cape of Good Hope	8,455	18,877	77,141	95,882	87,392	64,949	71,372
Natal	93	1,884	8,338	1,802	3,129	1,837	13,468
Rhodesia	258	—	2,432	57,526	77,223	208,761	240,232
Canada	73,961	92,147	209,652	184,517	159,268	413,119	286,857
Other British Possessions.	14	791	4,066	2,083	6,723	4,201	36,020
Total from British Possessions.	82,781	113,699	301,629	341,810	333,735	692,867	647,949
Total ...	150,963	181,010	359,822	537,496	403,585	829,038	686,236

Value of Imports and Exports of Asbestos Manufactures into and from the United Kingdom.

Years.				Imports.	Exports.
				Value	Value
			(£).	(£).	
1913	...	...	...	251,533	104,654
1914	...	...	...	203,304	146,956
1915	...	...	...	190,693	174,904
1916	...	...	...	114,237	230,589
1917	...	...	...	37,380	203,816
1918	...	...	...	11,030	128,915
1919	...	...	...	48,511	487,445

*Exports of Unwrought Asbestos from the United Kingdom.
(Colonial and Foreign Produce.)*

To	Quantity (long tons).						
	1913.	1914.	1915.	1916.	1917.	1918.	1919.
Belgium ...	—	—	—	—	—	—	701
Germany ...	269	163	—	—	—	—	—
Netherlands ...	—	16	18	131	270	—	486
France ...	185	73	885	858	783	761	1,237
Spain ...	—	—	—	252	180	—	396
Switzerland ...	—	—	348	482	220	—	813
Italy ...	221	144	1,522	1,025	575	55	568
United States of America.	2	62	—	609	460	—	187
Other Foreign Countries.	10	38	2	72	—	—	231
Total to Foreign Countries.	687	496	2,775	3,429	2,488	816	4,619
Total to British Possessions.	2	12	1	—	—	—	1
TOTAL ...	689	508	2,776	3,429	2,488	816	4,620
Value (£).							
Belgium ...	—	—	—	—	—	—	18,756
Germany ...	4,484	2,699	—	—	—	—	—
Netherlands ...	—	343	347	3,081	9,100	—	22,765
France ...	2,595	1,646	26,201	32,451	35,972	38,145	64,956
Spain ...	—	—	14	4,667	4,717	—	12,463
Switzerland ...	—	—	5,225	8,990	6,282	—	33,465
Italy ...	6,339	3,897	26,909	29,661	30,688	3,330	29,121
United States of America.	30	2,413	—	25,759	21,112	—	11,546
Other Foreign Countries.	397	1,270	101	2,158	—	—	13,329
Total to Foreign Countries.	13,845	12,268	58,797	106,767	107,871	41,475	206,401
Total to British Possessions.	8	553	10	—	—	—	75
TOTAL ...	13,853	12,821	58,807	106,767	107,871	41,475	206,476

Value of Exports of Asbestos Manufactures from the United Kingdom.

(Colonial and Foreign Produce.)

Year.						Value (£).
1913	...	...	...	...	...	19,793
1914	...	...	...	...	...	13,855
1915	...	...	...	...	...	14,913
1916	...	...	...	...	...	16,746
1917	...	...	...	...	...	4,803
1918	...	...	...	...	...	453
1919	...	...	...	...	...	7,467

Rhodesia.*

Both chrysotile and amphibole asbestos occur abundantly in many localities in Southern Rhodesia.

Chrysotile occurs in large deposits in the Victoria and Belingwe districts, where mining operations in recent years have been conducted on a considerable scale.

In the Victoria district the fibre occurs in narrow veins up to 2 inches in width, traversing serpentine in the vicinity of a series of granitic intrusions. The principle mining areas are situated near Mashaba, where there are two companies working on a commercial scale. In one of the Mashaba asbestos mines, the proved fibre zone is about 1,000 feet in length by 200 feet in width, with an east and west strike, and a southerly dip of about 45°. The fibre in this mine is rarely more than $\frac{3}{4}$ of an inch in length. In the year 1914 treatment plants were installed to separate the fibre. The material after treatment is classed as No. 1 with fibre over $\frac{3}{4}$ of an inch, and No. 2 with fibre between $\frac{3}{4}$ of an inch and $\frac{5}{16}$ of an inch in length. The distance of the Mashaba asbestos mines from Fort Victoria railway station is from 25 to 28 miles.

In the year 1915 the discovery of the Shabani fields in the Belingwe district gave a great impetus to asbestos mining in Rhodesia, many mines were opened up, and in 1916 machinery was installed to treat the fibre produced.

The asbestos quarries of the Shabani area are situated in a belt of serpentine hills about 16 miles north-east of Belingwe, the formations striking approximately east and west. The asbestos-bearing serpentine lies on a footwall of talc-schist. So

* S. Afr. Journ. Ind., F. P. Mennell, 1918, 1, 1411. Annual Reports of the Secretary of Mines, Southern Rhodesia. Annual Reports of the Rhodesia Chamber of Mines. Annual Statements of the Trade and Shipping of South Africa, and of Southern and Northern Rhodesia.

far as it has been explored, the Shabani asbestos area is about six miles in length by a mile in width, but its limits have not yet been clearly defined. The fibre in this area varies from $\frac{1}{8}$ -inch to 2 inches in length.

In both the Belingwe and Victoria districts the fibre is of excellent quality, the veins being almost entirely of the "cross" fibre type. "Slip" fibre occurs on some of the Belingwe claims, where the serpentine has been subjected to severe stresses resulting in the formation of a crushed zone.

Asbestos occurs also in the Lomagundi district, in a short range of serpentine hills running approximately east and west and forming a spur of the Umvukwe mountain range. The asbestos claims are situated on the Umvukwe ranch (on which deposits of chromium ore also occur), about 42 miles to the north-east of Sinoia, which is connected by railway with Salisbury. Seams of fibre ranging from $\frac{1}{4}$ of an inch to 2 inches have been exposed, but only a small amount of exploratory work has as yet been done on the deposits.

In the Bulawayo district, asbestos claims have been taken up about 52 miles north of Bulawayo and about three miles south-west of the Lonely Gold Mine. In this area there is a wide belt of serpentine, which forms a series of low-lying, rugged hills, on the northern extremity of which the Lonely Gold Mine is situated, the asbestos deposits being found in the southern portion of the hills.

The yield of asbestos fibre in the Mashaba area is said to range from 1 to about 1.5 per cent. of the rock broken, and that of the Shabani area from 1.5 to about 3 per cent.

Production of Asbestos in Southern Rhodesia.

Year.	Quantity (long tons).	Value (£).
1913	259	5,224
1914	435	8,612
1915	1,795	32,190
1916	5,497	99,059
1917	8,537	189,890
1918	7,655	158,684
1919	8,749	425,240

Exports of Unwrought Asbestos from Southern Rhodesia.
(Domestic Produce.)

To	Quantity (long tons).						
	1913.	1914.	1915.	1916.	1917.	1918.	1919
United Kingdom ...	222	151	1,648	5,103	8,669	6,967	7,921
Union of South Africa.	—	—	9	2	219	266	161
Australia ...	—	—	—	—	—	—	375
France ...	—	—	—	—	—	216	—
Holland ...	—	—	—	—	—	—	203
Portuguese East Africa.	—	—	—	—	—	1	—
United States ...	—	—	—	—	10	—	4
Japan ...	—	—	—	—	—	—	15
Total ...	222	151	1,657	5,105	8,898	7,450	8,679
	Value (£).						
United Kingdom ...	2,496	1,686	27,194	88,831	160,717	185,549	214,543
Union of South Africa.	—	—	150	42	6,167	4,577	4,281
Australia ...	—	—	—	—	—	—	13,643
France ...	—	—	—	—	—	10,025	—
Holland ...	—	—	—	—	—	—	6,786
Portuguese East Africa.	—	—	—	—	—	8	—
United States ...	—	—	—	—	330	—	152
Japan ...	—	—	—	—	—	—	805
Total ...	2,496	1,686	27,344	88,873	167,214	200,159	240,210

Value of Imports of Asbestos Manufactures into Southern Rhodesia.

From	Value (£).						
	1913.	1914.	1915.	1916.	1917.	1918.	1919.
United Kingdom ...	65	21	31	84	100	289	61
Union of South Africa.	—	—	—	—	—	527	23
Germany ...	—	3	—	—	—	—	—
Italy ...	—	—	—	—	—	7	—
United States ...	—	1	3	3	1	103	29
Total ...	65	25	34	87	101	926	113

Union of South Africa.*

The Union of South Africa contains asbestos deposits of large size. The material mined during the period under review consisted chiefly of crocidolite and amosite, but chrysotile is also worked. In spite of the commanding position occupied by chrysotile in the world's markets, the use of crocidolite and amosite for the manufacture of asbestos articles may be expected to increase. Asbestos goods are now being manufactured in South Africa.

Transvaal.—Within the limits of this province the asbestos minerals known to occur in economic quantities include chrysotile, crocidolite, amosite, and tremolite.

Amosite is found only in the north-eastern Transvaal between Lydenburg and Pietersburg. The deposits occur at the base of the Pretoria Series in a banded siliceous ironstone of sedimentary origin.

In the year 1915 the total output of asbestos in the Transvaal amounted to only 49 tons, but by the year 1917 the output had risen to 2,851 tons, owing chiefly to the discovery and exploitation of the amosite deposits in the Lydenburg district.

So far as is known at present, the amosite-bearing strata in this district extend for a distance of more than 60 miles, with an average width of about 6 miles. Within this area the mineral occurs as interbedded cross-fibre veins, invariably associated with the banded ironstone. The width of the veins varies up to a maximum of about 12 inches. The veins are worked by underground mining, and have been followed for a distance of 300 feet along the dip, further progress being stopped by water.

Three vein-groups can be recognized along the principal asbestos horizon. The upper group is not worked at present. In the middle group there are several veins, most of which carry amosite of economic value. Below these there is a seam carrying good fibre in places only. The only associated rock between the seams, apart from magnesite, is siliceous ironstone.

The principal mines are the Egnep and Amosa situated near the farms Penge and Streatham, which furnish about four-fifths of the total output. The maximum length of fibre obtained in this district is 11 inches, and lengths of from 4 inches to 7 inches are continuous over great stretches along the principal horizon.

After grading and drying, the fibre is put up into bags and transported by ox-wagon to Lydenburg station, 65 miles distant.

In addition to the Penge-Streatham deposits, well developed amosite veins are worked as far north as Uitval, 50 miles by road from Pietersburg Station.

* Asbestos in the Union of South Africa, A. L. Hall. Union of South Africa Geol. Surv. Memoir No. 12, 1918. Annual Reports of the Government Mining Engineer for the Union of South Africa. Annual Statements of the Trade and Shipping of the Union of South Africa, and of Southern and Northern Rhodesia.

In the Carolina district chrysotile occurs in bedded cross-fibre veins underlying an altered dolomite and associated with a basic intrusive sill. The whole formation lies at the base of the Pretoria series of slates and shales.

The mineral is known to outcrop over a length of twenty miles. Mining operations at the present time are restricted to the Diepgezet and Goedverwacht districts.

Previous to 1914 asbestos-mining at Diepgezet was carried on intermittently, but since that year there has been a regular and increasing output.

The fibre is of good quality and pale-green or olive-green colour when massive. The teased fibre has a pure-white appearance, and commands a high price in the market. It has been stated that during the year ending September, 1918, for every ton of asbestos obtained, 42 tons of rock were broken; and that 62 per cent. of the fibre exceeded 1 inch in length. Later developments show the proportion to be somewhat lower, at about 40 per cent. of 1 inch fibre. No machinery is used on the mines. Cobbing and sifting are all that are required to prepare the fibre for the market.

At Goedverwacht production started in the year 1915, since when the average yearly output has been about 120 tons. Hand-picking, cobbing, screening and bagging constitute the dressing operations on the mine. On an average month's output the proportion of cobbings to screenings is 3:7. After drying, the fibre is bagged and transported to Carolina railway station by ox wagon.

Crocidolite has been found only in the Haenertsburg goldfields and the Malips River areas of the Pietersburg district. The mineral occurs on the same geological horizon as the Pietersburg amosite, but is not necessarily confined to the lowest portion of the banded ironstone. In the Malips River district many of the veins are too thin for exploitation, and, where the fibre length is suitable, it often contains disseminated grains of iron ore. On the Haenertsburg goldfields cross-fibre crocidolite veins occur. The fibre has a lavender blue colour and is of good length and quality. On both these fields mining operations were confined to prospecting during the period under review.

Tremolite has been exploited only on Corea farm north of Mara Siding in the Zoutpansberg district.

Caprivi Province.—Crocidolite is the only variety of asbestos worked in this Province. The fibre area is confined to the Lower Griqua Town Series of banded ironstones and ferruginous or jaspersy rocks. This asbestos-bearing formation extends from the farm Lovedale, twenty miles south-east of Prieska, in a northerly direction as far as Mashowing River in British Bechuanaland, with a possible extension into the districts of Vryburg and Mafeking.

The crocidolite occurs in interbedded cross-fibre veins. The fibre is usually lavender-blue, but colour variations are not uncommon, particularly in the Daniels Kuil and Kuruman areas

where the colour is pale yellow or rusty brown. Such discoloured fibres are harsh to the touch, and command only a limited sale.

The asbestos-bearing belt, although presenting an uninterrupted succession of the Lower Griqua Town Series, may for convenience be divided into a southern and northern section. In the southern section are to be found the oldest and most productive workings. These are spread over an area extending from Prieska to Griqua Town. At the Westerberg mine, 35 miles north-west of Prieska, there are two distinct interbedded cross-fibre veins, and their persistence has been proved to a depth of 220 feet. The average monthly production of graded fibre amounts to 30 to 35 tons. In individual mines the average fibre lengths vary from about 0·5 inch on Naauwpoort and 0·75 inch on Leelykstaat, to about 1·0 inch on Stilverlaats. On a property at Keikams Poort, the proportion of fibre over 1 inch has been stated to be 50 per cent. Throughout the southern section cobbing, sieving, grading, and bagging, are the only operations required to prepare the fibre for market.

In the northern section a number of small companies have been mining asbestos for some years. The asbestos deposits and workings are scattered along a belt of country up to 18 miles wide, stretching from Owendale nine miles south-west of Daniels Kuil, to Tsenin on the Mashowing River, a distance of about 80 miles. Throughout the northern section the crocidolite is very irregularly distributed. Very little mining work is done; where a deposit is easily accessible it is worked as a quarry or open cut, and abandoned when the fibre deteriorates in quality, or other difficulties arise. Individual seams rarely persist for more than a few yards, when they pinch out and are succeeded by others farther on. The length of fibre is very variable. Lengths up to $4\frac{1}{2}$ inches have been found, but an average of about $\frac{3}{4}$ -inch is about the length for the northern section as a whole. The usual cobbing, sifting, and grading operations are carried out by hand, and the bagged material is transported by wagon to the railway, over distances varying from 100 to 130 miles.

The highly silicified variety of asbestos known as tiger's-eye or cat's-eye occurs sparingly, notably at Naauwpoort in the Hay district. It is quarried on a small scale and used in the manufacture of ornamental articles.

Natal.—Chrysotile occurs somewhat sparingly in Natal. The principal mine worked during the period under review was the Sitilo, situated between Eshowe and Krantzkop in the Tugela Valley, Zululand. The chrysotile occurs in a number of small cross-fibre veins traversing a dark-green serpentine. The fibres average $\frac{1}{4}$ -inch to $\frac{1}{2}$ -inch in length; they are pale-green in colour, and of inferior quality.

Tremolite has been worked on the Klip River Location, 25 miles from Dundee.

Sales and Shipments of Asbestos in the Union of South Africa

Year.	Transvaal.		Cape Colony.		Natal.		Totals.	
	Quantity long tons.	Value (£).	Quantity long tons.	Value (£).	Quantity long tons.	Value (£).	Quantity long tons.	Value (£).
1913	—	—	837	15,559	21	429	859	16,028
1914	27	1,430	1,037	18,657	—	—	1,063	20,087
1915	49	2,733	1,860	33,166	—	—	1,909	35,899
1916	363	8,490	3,775	74,293	19	287	4,157	83,070
1917	2,851	37,486	2,678	49,485	25	393	5,554	87,364
1918	830	9,829	2,446	44,148	4	60	3,280	54,037
1919	563	7,699	2,861	57,578	88	1,149	3,512	66,426

Exports of Unwrought Asbestos from Union of South Africa.
(Domestic Produce.)

To	Quantity (long tons).						
	1913.	1914.	1915.	1916.	1917.	1918.	1919.
United Kingdom ...	336	652	2,759	3,619	2,415	1,835	2,650
Australia ...	—	—	—	—	204	1,129	1,100
New Zealand ...	—	—	—	—	—	—	5
Belgium ...	—	—	—	—	—	—	195
France ...	35	40	—	—	49	80	9
Germany ...	265	279	—	—	—	—	—
Holland ...	—	—	—	—	—	—	186
Italy ...	377	196	—	—	—	—	—
Portuguese East Africa.	—	—	—	—	—	1	1
United States ...	2	—	—	287	2,271	100	709
Japan ...	—	—	—	103	480	250	74
Total ...	1,015	1,167	2,759	4,009	5,119	3,395	4,929
	Value (£).						
United Kingdom ...	5,023	11,859	44,486	60,529	40,661	29,303	43,788
India ...	—	—	2	—	—	—	—
Australia ...	—	—	—	—	4,468	20,679	21,646
New Zealand ...	—	—	—	—	—	—	150
Belgium ...	—	3	—	—	—	—	4,682
France ...	524	600	—	—	586	1,120	224
Germany ...	3,927	3,899	—	—	—	—	—
Holland ...	—	—	—	—	—	—	2,569
Italy ...	5,641	2,922	—	—	—	—	—
Portuguese East Africa.	—	—	—	—	—	16	35
United States ...	28	—	—	4,713	33,601	2,198	11,819
Japan ...	—	—	—	3,584	7,212	4,749	2,031
Total ...	15,143	19,283	44,488	68,826	86,528	58,065	86,944

Value of Exports of Asbestos Manufactures from Union of South Africa.

(Foreign Produce.)*

To	Value (£).						
	1913.	1914.	1915.	1916.	1917.	1918.	1919.
United Kingdom ...	—	—	1	—	—	—	—
British East Africa	—	—	—	—	—	13	25
South West Africa Protectorate.	—	—	—	14	35	108	60
Mauritius ...	—	10	—	—	—	—	—
Belgian Congo ...	1	4	—	65	192	—	143
Portuguese East Africa.	—	28	151	80	879	363	150
Portuguese West Africa.	—	—	—	—	—	4	—
Total ...	1	42	152	159	1,106	488	378

* Asbestos manufactures (South African produce) value £57 and £440 were exported in 1915 and 1919 respectively.

Value of Imports of Asbestos Manufactures into Union of South Africa.

From	Value (£).						
	1913.	1914.	1915.	1916.	1917.	1918.	1919.
United Kingdom ...	3,756	2,925	4,102	8,852	3,877	2,462	21,431
Canada ...	—	18	283	47	—	252	1,021
Australia ...	—	—	—	—	—	1	—
Austria-Hungary ...	18	—	—	—	—	—	—
Belgium ...	1,788	871	98	—	—	—	314
Denmark ...	—	71	—	—	—	—	—
France ...	126	6	—	—	—	—	2
Germany ...	1,115	366	3	—	—	—	—
Holland ...	215	1,288	909	387	340	—	1,309
Italy ...	129	—	558	528	—	—	—
Sweden ...	8	22	17	41	222	121	47
Switzerland ...	164	2	351	1,202	—	—	—
United States ...	1,126	509	102	419	559	568	625
Total ...	8,445	6,078	6,423	11,476	4,998	3,404	24,749

Canada.*

Canada produces more asbestos than any other country. With the exception of a small production of actinolite from the deposits in Hastings county, Ontario, the asbestos produced in Canada is of the chrysotile variety.

Quebec.—The chief chrysotile deposits occur in the province of Quebec, and are confined to two distinct geological formations, namely, the Laurentian crystalline rocks in the Templeton area north of Ottawa, and the serpentine mountain belt that extends from the boundary of Vermont to the Gaspé Peninsula.

In the Laurentian formation, asbestos occurs in serpentine deposits closely associated with a massive crystalline-limestone belt which extends over a distance of several hundred miles. Only in the district north of Ottawa does the serpentine carry asbestos. The principal area where these deposits have been worked is Templeton township.

The asbestos is found in a large number of small veins traversing the serpentine in parallel layers. The veins vary in width up to half an inch. The asbestos fibre has a wavy appearance, and is light-yellow or light-green in colour. It is of fine quality and well adapted for spinning.

The asbestos-bearing deposits are very irregularly distributed throughout the limestone, and are individually limited in extent. Few of the deposits when opened up have been found to extend more than several yards in any direction.

Other localities where asbestos occurs in the Laurentian rocks are the township of Portland West; near St. André Avelin, Côte St. Pierre; in the township of Wentworth south of Silver Lake; on Blanche Lake, in the township of Mulgrave, and at several points along the Ottawa River. Throughout the Laurentian series the asbestos deposits are too small and too scattered to allow of profitable mining operations. Considerable prospecting work has been carried out at different points, but the results have always been disappointing.

The Eastern Townships of the province of Quebec have for many years been the most productive asbestos mining area in the world. Within this region asbestos is known to occur in three separate areas, namely:—(1) the region covering the Gaspé Peninsula; (2) the Thetford and Black Lake area; (3) the Danville-Orford-Potton area.

In the Gaspé Peninsula asbestos veins have been found in a band of serpentine, associated with hornblende rock, near the mouth of the Dartmouth river. Difficulty of access has prevented this region from being adequately explored.

* Chrysotile-Asbestos, by F. Cirkel. Canada Dept. of Mines, 1910. Annual Reports on the Mineral Production of Canada. Annual Reports on Mining Operations in the Province of Quebec. Annual Reports on the Trade and Commerce of Canada.

The workable deposits of chief importance are confined to a serpentine belt near Black Lake and Thetford. The serpentine of this belt generally occurs as disconnected masses, but occasionally it forms mountain ridges of considerable altitude; notably in the vicinity of Black Lake where most of the productive mines are situated. The rock carrying good asbestos veins is generally dark-green or greyish-green in colour. It frequently contains numerous particles of magnetite and chrome iron-ore. Much of the serpentine is traversed by granite intrusions which range in size from small bands one or two feet in width, up to intrusions one hundred feet in thickness. In some places the serpentine is intimately associated with steatite, and chrome iron-ore has been found in pockets up to ten or fifteen feet in thickness. Wherever these two minerals occur together asbestos mining has not been profitable.

The veins of asbestos traverse the serpentine in all directions. As a rule the fibre lies at right angles to the walls of the veins, but occasionally it has been drawn out by rock movement, and then appears of greater length and parallel with the walls of the vein. Such fibre is known as "slip fibre."

The veins vary in width from $\frac{1}{4}$ inch to $\frac{1}{2}$ inch, and exceptionally, fibre has been obtained several inches in length. The fibre is generally dark-green, and has a silky appearance when drawn into threads. It is of good quality and well adapted for spinning.

Included in the Thetford and Black Lake area are the East Broughton deposits, where the serpentine occurs enclosed in a highly quartzose slate, probably of pre-Cambrian age. Most of the serpentine is shattered, and is easily mined. The fibre is usually short but occurs up to two inches in length and is of excellent quality.

In the Danville area the serpentine rock is much affected by faults, and some of the larger veins are cut off by intrusive dykes. Asbestos up to $\frac{1}{2}$ inch in length occurs abundantly, and the whole of the serpentine is impregnated with fine short fibre giving a first-class milling material. It has been stated that 70 to 80 per cent. of the rock mined goes through the mill.

Opencast methods of mining are adopted almost invariably throughout the Canadian asbestos fields. The broken rock after removal from the quarry is either hand-cobbed to remove first-grade asbestos, containing fibre over $\frac{3}{4}$ inch in length, known locally as crude asbestos, or the whole product is subjected to mechanical crushing which renders the mineral more amenable to subsequent treatment by pneumatic processes. The material thus obtained is known as fines or mill-stock.

Dressing operations vary somewhat with the character of the rock treated, but practically all the asbestos-mining companies have installed machinery for the crushing, fibrizing, screening, and grading of the mine product.

Exceptionally high prices were obtained for asbestos during the greater part of the war period. No new discoveries of asbestos were made during the period under review, but many known unworked deposits were opened up. The greatly increased production required to supply the world's urgent demands was met by improved methods of handling the asbestos rock at the quarries.

During the year 1918 about $2\frac{3}{4}$ million tons of asbestos rock were broken and hoisted.

It has been ascertained by diamond drilling, sinking and drifting, that large reserves of asbestos exist in each of the principal mining fields, and that the quality of the fibre does not deteriorate in depth.

Ontario.—In the year 1916 chrysotile asbestos was mined in Ontario for the first time. The asbestos-bearing rock is serpentine seamed with stringers and veins of asbestos up to $2\frac{1}{2}$ inches in width. The only deposit at present worked occurs at Deloro, near Porcupine, where portions of the rock carry as much as 12 per cent. of asbestos.

In the year 1916, 500 lb. of asbestos valued at £21 were shipped, and there was a further shipment of 9 tons in 1917 valued at £448. No chrysotile asbestos was produced in the year 1918, but 204 tons of actinolite were ground and shipped to the United States from Actinolite.

The Governors of the Bureau are indebted to Mr. C. S. Bell, of Bell's United Asbestos Co., Ltd., for the following statement of representative prices of Canadian asbestos fibre during the period under review:—

Representative Prices of Canadian Asbestos Fibre.
(In dollars per short ton.)

	1913-14.	1914-15.	1915-16.	1916-17.	1917-18.	1918-19.	1919-20.
No. 1 Crude	\$ 300-350	\$ 300-350	\$ 400-500	\$ 750-1000	\$ 1000-1250	\$ 1500-2000	\$ 2500-3000
No. 2 Crude	\$ 175-200	\$ 175-200	\$ 250-300	\$ 400-500	\$ 600-750	\$ 850-1000	\$ 1250-1600
2B Long Spinning Fibre	\$ 100-125	\$ 125-150	\$ 200	\$ 300-350	\$ 400-450	\$ 500	\$ 650-700
X Medium Spinning Fibre	\$ 60-65	\$ 70-75	\$ 100	\$ 200-250	\$ 250-275	\$ 275-350	\$ 400-450
XX Paper Stock	\$ 20-25	\$ 19-25	\$ 35-40	\$ 60-70	\$ 60-70	\$ 60-70	\$ 60-70
C Short Fibre	\$ 8-10	\$ 8-10	\$ 15-18	\$ 20-25	\$ 20-25	\$ 25-30	\$ 25-30
Medium Slate Fibre	\$ 25-30	\$ 35-40	\$ 75-80	\$ 80-100	\$ 90-100	\$ 100-110	\$ 100-115
Long Slate Fibre... ..	\$ 45-50	\$ 50-55	\$ 80-100	\$ 100-125	\$ 125-140	\$ 140-150	\$ 150-160

Production of Asbestos in Canada.

Year.	Crude (long tons).	Mill-stock (long tons).	Total (long tons).
1913	4,487	113,874	118,361
1914	3,627	92,506	96,133
1915	3,580	91,582	95,142
1916	4,835	100,743	105,578
1917	5,596	120,960	126,556
1918	3,851	124,235	128,086
1919	3,620	133,049	136,669

Canada—Sales and Shipments of Asbestos and Asbestic.

Year.	Asbestos.						Asbestic.	
	Quantity (long tons).			Value (£).*			Quantity (long tons).	Value (£).*
	Crude.	Mill Stock.	Total.	Crude.	Mill Stock.	Total.		
1913	5,054	117,224	122,278	206,075	592,081	798,106	21,549	3,962
1914	3,704	82,495	86,199	161,081	441,474	602,555	18,778	3,654
1915	4,795	94,439	99,234	224,229	516,014	740,243	22,946	4,546
1916	5,255	113,887	119,142	388,952	694,339	1,083,291	18,491	6,057
1917	4,806	116,178	120,984	572,515	923,964	1,496,479	16,321	9,851
1918	3,296	123,009	126,305	516,325	1,345,509	1,861,834	14,997	7,063
1919	3,408	118,198	121,606	668,115	1,552,499	2,220,614	16,755	11,268

* Converted into £ sterling at the rate of 1 dollar = 4s. 2d.

Canada—Shipments of Actinolite.

Year.				Quantity (long tons).	Value £
1913	...	...	...	59	150
1914	...	...	...	106	272
1915	...	...	...	196	504
1916	...	...	...	223	573
1917	...	...	...	107	275
1918	...	...	...	204	522
1919	...	...	...	71	183

Exports of Asbestos from Canada.

Year.	Asbestos.		Sand and Waste.		Manu- factures.
	Quantity (long tons).	Value (£).	Quantity (long tons).	Value (£).	Value (£).
1913	92,689	593,343	22,112	28,904	Not stated.
1914	72,394	478,885	16,956	22,614	26,042
1915	75,521	569,728	22,413	32,794	988
1916	86,406	806,763	29,968	50,265	11,597
1917	83,868	1,021,526	46,507	89,782	8,492
1918	106,655	1,622,231	19,771	47,512	48,438
1919	106,359	2,005,353	22,595	54,328	

Exports of Asbestos from Canada.

(Domestic produce.)

Year.	To Great Britain.		To United States.		To Germany.		To Other Countries.		Total.	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
	(long tons).	(£).	(long tons).	(£).	(long tons).	(£).	(long tons).	(£).	(long tons).	(£).
1913	6,446	44,138	69,783	441,732	750	7,602	15,710	99,871	92,689	593,343
1914	9,997	79,684	52,055	324,029	2,454	19,785	7,887	55,387	72,394	478,885
1915	19,580	155,001	50,586	358,780	—	—	5,355	55,947	75,521	569,728
1916	12,829	128,214	65,354	589,592	—	—	8,222	88,957	86,406	806,763
1917*	—	—	—	—	—	—	—	—	83,868	1,021,526
1918	9,237	186,326	88,555	1,273,856	—	—	8,862	162,049	106,655	1,622,231
1919	...	...	...	...	...	...	...	...	...	...

* Details not published in 1917.

Value of Imports into Canada of Wrought Asbestos.

Fiscal years ending March 31. .

	Value (£).						
	1913.	1914.	1915.	1916.	1917.	1918.	1919.
United Kingdom.	9,147	10,376	6,979	8,525	16,231	13,382	10,317
Newfoundland.	—	—	1	—	—	—	—
Austria-Hungary..	408	114	—	—	—	—	—
Belgium ...	720	557	361	—	—	—	—
France ...	71	112	—	7	—	—	—
Germany ...	725	1,166	638	—	42	108	—
Netherlands	109	—	7	—	—	—	—
Portugal ...	—	—	—	—	36	15	11
Sweden ...	—	—	—	—	—	—	²
United States.	92,395	86,529	39,204	31,444	65,886	96,506	125,022
TOTAL ...	103,575	98,854	47,190	39,976	82,195	110,011	135,352

Value of Imports of Asbestos into Canada.

Year.	Value (£).					
1913	108,350
1914	58,761
1915	35,186
1916	69,723
1917	111,964
1918	125,980
1919	13,667

Cyprus.*

Deposits of asbestos occur at Amiandos, near Troodos, in Cyprus. The mineral mined is a short-fibre chrysotile. In the year 1907 a concession was granted to the Cyprian Mining Company, of Trieste, to mine asbestos in the Troodos Forest for ninety-nine years; but this concession was cancelled in the year 1919, and a mining lease was granted to a local syndicate.

* The Handbook of Cyprus, Luke & Jardine, 1920, p. 221; and Colonial Report (Annual).

Exports of Asbestos from Cyprus.

Year.				Quantity (long tons).	Value (£).
1913	...	...	...	1,168	—
1914	...	...	...	246*	1,913
1915	...	...	...	1,099	9,509
1916	...	...	...	1,291	14,681
1917	...	...	...	1,069	14,072
1918	...	...	...	228	3,080
1919	...	...	...	1,331	25,355

* Work interrupted by a fire.

India.*

Asbestos and asbestiform minerals are known to occur at many localities in India, of which the following may be mentioned:—Tumkhera Khurd, in the Bhandara district of the Central Provinces, which furnishes a few tons from time to time; Dev Mori, in the Idar State of Bombay, where a considerable amount of amphibole-asbestos occurs in rod-like masses yielding long but brittle staple fibre up to 8 inches in length; Seraikela State, Singhbhum, where chrysotile asbestos is obtainable in long columnar masses also suffering from the same defect of brittleness.

The most promising deposits known at present occur in the Hole-Narasipur Taluk and in the Kabbur block, both in the Hassan district of Mysore. The mineral is the amphibole variety and appears to be an alteration product of amphibolites in proximity to granitic intrusions. It occurs in bunches and aggregates of fibrous material, and at Kabbur long sticks several feet in length are obtainable. The serious defects are brittleness and lack of tenacity of the fibres. It has been suggested that these may prove to be merely surface modifications, and deeper workings have been recommended. A serious attempt is being made to start an asbestos industry on a large scale in Mysore, and Indian-made asbestos boiler covering compositions are already on the market.

Most of the asbestos production, shown in the following table, was derived from the Hassan district.

Production of Asbestos in India.

Year.				Quantity (long tons).	Value (£).
1913	...	...	...	—	—
1914	...	...	...	5	23
1915	...	...	...	—	—
1916	...	...	...	—	—
1917	...	...	...	148	303
1918	...	...	...	357	965
1919	...	...	...	388	1,656

* Mineral Production of India (Annual). Rec. Geol. Surv. India.

Australia.*

New South Wales.—Deposits of asbestos are known to occur in many localities in New South Wales. Specimens have been obtained from Gundagai, the Broken Hill District, Springfield, Barraba, Byng, the Orange district, Rockley, Woodsreef and other areas. The mineral occurs in cross-fibre veins traversing serpentine. It is usually white or light-green, and inferior in strength, flexibility, and texture to the Canadian chrysotile asbestos.

During the period under review prospecting operations resulted in the production of ten tons of asbestos from the Gundagai area in the year 1917, and in the year 1918 one hundred and eighty tons of asbestos-bearing rock were raised in the Barraba division. The output for 1919 is given as 1,739 tons of rock containing 143 tons of fibre.

Queensland.—Asbestos is known to occur in the serpentine belt, which extends from Balnagowan near Keppel Bay to Yaamba, Princhester, and Marlborough, in the Rockhampton district. Prospecting operations carried out in the Rockhampton area during the later part of the period under review proved the existence of considerable quantities of rather inferior asbestos fibre of coarse texture. The serpentine in which it occurs is seamed with asbestos veins up to a foot or more in thickness but the asbestos fibre is harsh and lacks tensile strength.

Small quantities of fibre from this district have been used for the manufacture of asbestos-magnesia compositions

South Australia.—Asbestos occurs in many places in South Australia. During the period under review, mining operations have been confined to prospecting, notably in the hundred of Bright, 8 miles from Robertstown, and at Section 1 B Minbrie, 6 to 7 miles from Cowell. In the former area several seams of crocidolite were opened up during prospecting operations. The thickness of the veins was found to be from 1 inch to 4 inches. The fibre obtained was of good quality, but it appears that the work done was not sufficient to prove the value of the deposit.

At Minbrie, chrysotile asbestos ranging up to $1\frac{1}{2}$ inch in length was found in narrow veins traversing highly serpentinized magnesian marble. The average width of the asbestos seams does not exceed $\frac{1}{4}$ inch. The fibre is white and has good tensile strength, but is reported to be unsuitable for spinning.

Western Australia.—Chrysotile asbestos is known to occur in many localities in Western Australia, notably at Soanesville, in the Pilbara goldfield. Some years ago these deposits were extensively prospected by means of shafts and tunnels. The fibre was found to occur in two parallel bands traversing serpentine rock.

* Annual Reports of the Department of Mines, New South Wales. Annual Reports of the Under Secretary for Mines, Queensland. Review of Mining Operations in South Australia. Annual Reports of the Department of Mines, Western Australia. Annual Reports of the Secretary for Mines, Tasmania.

The bands are separated by a dolerite dyke, which forms the footwall of one band and the hanging wall of the other. The asbestos veins have generally a ribbon structure, though at times they occur as a network of veins. The quality of the mineral varies greatly; in some sections of the deposit there is abundant asbestos of good quality, in others the quality is poor and not worth mining. The amount of fibre in the rock may be taken at 10 to 30 per cent. Very little fibre capable of extraction by cobbing was found, the bulk of the material being suitable for mill treatment only. The unfavourable situation of the deposits and high working costs have so far prevented profitable mining operations on these fields.

Other localities where asbestos has been noted are Jarman Island, West Pilbara goldfield; Menzies, North Coolgardie goldfield; Hannans Lake; East Coolgardie goldfield; Mount Magnet, Murchison goldfield; the Upper Henry River; and near Moora.

Tasmania.—Deposits of chrysotile asbestos are known to occur in the serpentine belt which extends for a distance of 3 miles in the Beaconsfield district. These deposits do not occur uniformly throughout the belt, and are limited chiefly to the northern end on the slopes of the hills, and in the flats of Anderson's Creek. The mineral occurs in narrow veins, traversing the rock without system or continuity. The fibre is of good quality for the purpose for which it is quarried, namely, the manufacture of panelling slabs for roofing and lining buildings. The larger proportion of the fibre does not exceed $\frac{1}{8}$ inch in length, but fibre up to 1 inch in length has been found.

Very little interest was taken in these deposits until the year 1916, when prospecting operations were resumed at Anderson's Creek and 15 tons of asbestos rock valued at £30 were produced. In the following year a plant was installed to separate asbestos fibre from the rock, and the output was 271 tons of rock valued at £271. Production for 1918 showed an increase, the output for the year being 2,854 tons, valued at £5,008. The returns for the year 1919 are given in terms of asbestos fibre, and 51 tons of this material, valued at £25 per ton, were produced in that year.

FOREIGN COUNTRIES.

Italy.*

The principal asbestos occurrences in Italy are situated in the Susa and Aosta Valleys, and in the Valtellina district of Lombardy. Italian asbestos is of the tremolite (amphibole) variety.

In the Susa valley the asbestos occurs on the northern side of the valley, at an elevation of 6,000 feet to 10,000 feet above sea level. The asbestos occurs as floss-fibre and white powder.

* Rivista del Servizio Minerario (Annual).

In the Aosta Valley the principal mining districts lie on either side of the railway from Ivrea to Châtillon, a distance of 30 miles. The asbestos is known as "grey fibre," and is made up of long soft fibres.

The mineral in the Valtellina district is similar in character to that obtained in the Aosta Valley. The chief mines are situated in the Val Malenco not far from the town of Sondrio at an altitude of 3,600 feet to 7,200 feet above sea level.

Throughout the Italian asbestos fields the veins are mined by shafts and levels, dynamite being used to blast the rock. All the asbestos mined during the day is bagged and loaded on sledges drawn down the mountain side by hand labour. At the factories the fibre is graded into three qualities: (1) fibre suitable for spinning, (2) short fibre used in the manufacture of mill-boards and paper, (3) asbestos powder, part of which is reserved for conversion into cement and paint, and the remainder sold for manure.

Production, Imports and Exports of Asbestos in Italy.

Year.	Production.		Imports.		Exports.	
	Quantity (long tons).	Value (£).*	Quantity (long tons).	Value (£).*	Quantity (long tons).	Value (£).*
1913	172	3,834	4,674	62,697	661	14,793
1914	168	3,810	2,666	37,934	501	11,594
1915	160	7,824	5,294	75,319	146	3,372
1916	81	2,172	5,341	151,984	255	15,534
1917	84	2,841	3,669	343,031	163	18,216
1918	59	2,280	3,110	290,803	116	12,947
1919						

* Converted into £ sterling at the rate of 25 lire = £1.

Russia.

Before the war Russia held second place as a producer of asbestos. The principal mines are situated in the serpentine areas of the Urals. There are also deposits of considerable extent in Siberia. Asbestos is known to occur in the Caucasus, but the veins are small and the fibre is of poor quality.

The chief mining district in the Urals lies north of Ekaterinburg in the Bagenova district of Perm. The asbestos is harsher than Canadian asbestos, but is suitable for spinning.

The asbestos occurs in cross-fibre veins traversing serpentine. Few of the veins attain a greater length than 100 feet. Mining is carried out by shallow open cuts, and the serpentine is so decomposed that it can be broken by a pick to a depth of 70 feet. Some of the work is still done in a very primitive manner by the agricultural population of the district. Work is confined to the

summer months, but is frequently interrupted to allow harvesting operations to be carried out. A few of the mines have adopted modern methods, and possess mining machinery equipped with electrical power.

The broken rock from the quarries is cobbled by hand and graded into five qualities according to the fibre lengths, which vary from $1\frac{1}{2}$ inch to $\frac{1}{5}$ inch.

The known Siberian deposits of asbestos are in the Angarsk district near Irkutsk and on the Kamuisht river in the Yenissei Government. Asbestos deposits have also been reported from many districts in the Altai Mountains. The Siberian deposits are little developed and do not contribute an important part of the Russian production.

There is a small output of asbestos from Sharopan, Vzhinevi, and Lechgum, in the Government of Kutais in the Caucasus.

United States.*

The United States is the country of chief importance in the manufacture of asbestos goods. The industry depends almost entirely upon imported Canadian fibre. Very little high-grade asbestos suitable for spinning has so far been found within the United States. In the year 1913 chrysotile asbestos was discovered in the Grand Canyon, Arizona, in the neighbourhood of Ash Creek, and there was a small production in that year. This deposit was extensively mined during the period under review, and a new discovery north of Roosevelt Reservoir, on the Sierra Ancha, was opened up for mining in the year 1917. Both these deposits contain chrysotile asbestos suitable for spinning.

The larger part of the American production of crude asbestos is obtained from the anthophyllite deposits near Sall Mountain in Georgia. The mineral is associated with crystalline schists of pre-Cambrian age, and composes the whole rock mass. Only the weathered portion of the deposit is suitable for quarrying, the unweathered rock being too hard for milling.

It is stated that 90 per cent. of the rock quarried appears in the finished product.

Milling operations consist of grinding and fibrizing to one grade suitable for the manufacture of cement, plaster, roofing material, etc.

Similar deposits are quarried in Idaho near Kamiah in Lewis county. The demand for this material is small, and there is only one active producer.

American manufacturers of asbestos articles and material hold the foremost position in the world's asbestos industry. This result is largely due to the close proximity of the Canadian asbestos to the American centres of industry.

A large number of the most valuable Canadian mines are owned or controlled by American capital.

* Annual Reports on the Mineral Resources of the United States. The Mineral Industry, 1913-1918.

Asbestos in the United States.

Year.	Production.		Imports.*		Exports.†		Apparent Consumption.‡	
	Quantity (long tons).	Value (£).||	Quantity (long tons).	Value (£).||	Quantity (long tons).	Value (£).||	Quantity (long tons).	Value (£).||
1913	982	2,292	86,737	401,814	—	—	—	—
1914	1,113	3,951	64,166	293,283	—	—	—	—
1915	1,546	16,032	83,541	412,809	—	—	—	—
1916	1,321	93,378	103,716	688,223	279§	1,278§	—	—
1917	1,503	105,428	119,739	941,911	632	24,287	120,610	1,023,052
1918	895	25,976	122,946	1,320,335	622	10,636	123,219	1,335,671
1919	1,261	67,819	120,777	1,535,351	999	32,795	121,038	1,570,375

* Mainly from Canada.

† Exports not separately recorded prior to July, 1916.

‡ Converted into £ sterling at the rate of 1 dollar = 4s. 2d.

† Production plus imports, minus exports.
§ Figures cover period July to December, 1916.

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